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Evaluation for Stalk Rotting in Some Dent Corn Inbred Lines Alone and in Top Cross Combination with a Single Cross

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EVALUATION FOR STALK ROTTING IN SOME DENT CORN
INBRED LINES ALONE AND IN TOP CROSS
COMBINATION WITH A SINGLE CROSS

BY

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EVALUATION FOR STALK ROTTING IN SOME DENT CORN

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This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree; but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser

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INTRODUCTION

Stalk rot is one of the major diseases of dent corn in the north central corn producing area of the United States. Besides *Diplodia zeae* (Schw.) Lev., and *Gibberella zeae* (Schw.) Petch. other stalk rotting microorganisms are *Fusarium moniliforme* Sheldon, emend. Snyder and Hansen, causing Fusarium stalk rot; *Sclerotium bataticola* Taub., causing charcoal rot; *Erwinia dissolvens* (Rosen) Burkh., causing bacterial stalk rot; *Pythium butleri* Subr., causing Pythium stalk rot; and *Nigrospora oryzae* (Berk. and Br.) Petch, causing Nigrospora stalk rot. Losses vary from year to year depending on weather, variety of corn and amount of inoculum present in or on the soil. Under favorable ecological conditions it is not uncommon to observe dying plants in the late stage of their development.

During the past two decades conscious effort has been made by plant breeders and plant pathologists of the corn belt to incorporate stalk rot resistance in new developing hybrids. The same effort has been made by plant pathologists and corn breeders at the South Dakota Agricultural Experiment Station. The present study was part of latter effort and was concerned with determining (a) the reactions of inbred lines alone and in top cross combination with the single cross SD26 x B8 to stalk inoculations with *D. zeae* and *G. zeae* and (b) to compare the reactions of those plants to each of the two fungi. In addition, the results from these inoculations were also compared with those from sterile water inoculated plants. The inbred lines comprised 80 developed by the Plant Pathology Department of the South Dakota Agricultural Experiment Station and 68 developed or acquired from other sources by the Agronomy Department of that same station.

REVIEW OF LITERATURE

Diplodia zeae (Schw.) Lév., the causal organism of stalk and ear rot was first described by Schweinitz in 1884, but it was not recognized as the primary pathogen of corn until Heald published his first account of diplodia ear rot in 1906 (14). The pathogenicity, nomenclature, life history and growth in culture of that fungus was worked out by Heald, Wilcox and Pool in 1909 (14). Burrill and Barrett reported slight growth of the fungus following artificial inoculation of corn stalks in Illinois (2). Stalk rot may be initiated from lesions within the leaf sheath and from roots. The rot more frequently develops in the stalks from adventitious roots and crowns, producing premature dying, leaning or lodging of plants. The ears from lodged plants frequently are of poor quality and generally rot when in contact with moist soil (5, 16, 27).

Gibberella zeae (Schw.) Petch. or *G. roseum f. cerealis* (Cke.) Snyder and Hansen., causes a pink ear rot, root and stalk rot and seedling blight of corn. It is generally the most important causal organism of stalk rot in the eastern and central section of the corn belt (7, 24). This fungus also occurs on the other cereal crops; namely, wheat, barley, oats, and rye. Typical symptoms are reddish lesions on the stalks, premature dying and lodging of plants. *G. zeae* produces bluish black, spherical, superficially borne perithecia in late fall (7, 11, 38).

Durrell (8,9) believed the presence of moisture abundance was the determining factor in the growth of *D. zeae* in stalks and the amount of rainfall in August determined the extent of the rot. Factors described by him as necessary for stalk rot epiphytotic were (a) the amount of precipitation in August followed by warm days, (b) maximum amounts of stored food in the plants, and (c) cessation of plant growth and loosening of the leaf sheaths. Durrell reported that D. zeae chiefly attacked the lower two or three internodes, rarely infecting the sixth or seventh internode. The second internode was often affected badly as compared to the first internode. There was practically no relationship between diplodia infection on the stalk, shank, and ear.

Hooker (17) reported varietial differences in degree of resistance and susceptibility to basal stalk rot but all lines were relatively susceptible to D. zeae in the internodes below the ear. In the varieties used he found resistance in one part of the plant was not necessarily associated with resistance in the remaining plant parts; but some plants showed fairly good resistance in several plant parts. He reported a greater degree of susceptibility in later maturing varieties. He also observed that the plants with naturally infected stalk rot organisms at the base very often had severely infected root systems.

Most investigators agree that the only feasible method of adequately controlling stalk rot is by the development of resistant varieties. Smith, Hoppe, and Holbert (33) compared the incidence of stalk rot under natural and artifical conditions. Artificial inoculations were made by hypodermically injecting a water spore suspension of D. zeae pycnidiospores. The coefficient of correlation between broken stalks and natural infection was +0.909; between pith spread and cortical spread, +0.821; and between the cortical spread and natural infection, +0.878. They concluded that the reaction to artificial inoculation was genetic and that relative resistance to D. zeae could be measured by artificial inoculations. Semeniuk (31, 32) found no perfect relationship between spread of D. zeae in stalks and sucrose retained after the leaves were clipped or ears removed, as plants with leaf area reduced were found to be more susceptible to the damage of stalk rot. Correlation coefficients in spread of D. zeae and G. saubinetii in the pith of inbred lines between years of 1938 and 1939 was highly significant, with values of +0.413 for D. zeae and +0.578 for G. saubinetii. He also obtained highly significant correlation within inbred lines with respect to the extent of rot caused by these two pathogens, but a non-significant correlation was obtained within hybrids.

Hooker (12) reported that the discoloration spread was most rapid during the period immediately following inoculations. He found that the rate of spread was most rapid in the first two weeks in the susceptible varieties. In varieties intermediate in resistance, the rate of spread was fairly constant during a four week interval following inoculations. There was practically no spread after the first week following inoculations in the resistant lines. Among the inbred lines the time of silking and inoculations had little or no effect on the development of the disease during the four week period after inoculations. Hooker suggested that similar internodes should be inoculated to measure comparative resistance to stalk rot among different lines or hybrids. The most satisfactory results could be obtained if the stalk rot ratings are made four weeks after inoculations.

Koehler (22, 23) reported a stalk rot epiphytotic in Illinois in 1946 in which there was no correlation for susceptibility between D. zeae and G. zeae. From later data obtained in 1957, he reported a highly significant correlation between these two pathogens among hybrids; but he also reported a significant interaction between these two fungi. He concluded there was a tendency for inbred lines to react similarly to D. zeae and G. zeae, but some of them reacted in the opposite manner to these fungi.

DeVay et al. (6) published the data on the stalk rot inoculations with D. zeae and G. zeae of 110 inbred lines, but apparently there was no correlation in the reactions of these two fungi.

Taylor (36) reported the reaction of corn inbred lines and hybrids to the inoculations with D. zeae resembled more the rot following corn borer damage than the rot arising from natural infection. He suggested that D. zeae could be used in a breeding program designed to obtain resistant varieties to stalk rot following corn borer.

Foley (12) reported that discoloration ratings did not depend on the development of the rot and were unsatisfactory. The ratings of the entries by stalk tissue discoloration was not always as constant as that by stalk break rating. He believed that the varietal differences to stalk rot could not be indicated on the basis of pith discoloration. He obtained greater differences in discoloration between the inoculation sites in resistant lines than in the susceptible lines. Foley observed that ratings of inbred lines on the basis of stalk discoloration were sometimes poor indicators of hybrid performance. He also showed that breakage and decomposition of stalks were variable because of other factors than inherent susceptibility as this was demonstrated by the simultanous occurrence of severely and slightly rotted plants within a hybrid.

Michaelson (26) reported a greater stalk rot development in smutted plants and in the plants with clipped leaves prior to inoculations than in non-smutted plants or in plants with leaves intact. Flooding pots with water reduced rot development and greatest spread of rot from _D. zeae_ and _G. zeae_ stalk inoculation occurred in the unsaturated pots. Boring holes, cutting roots, and the action of the corn borer apparently did not have an effect on the development of stalk rot. He also reported that under controlled temperatures of 65° F. and 85° F. _D. zeae_ and _G. zeae_ caused more severe stalk rot at the higher temperature.

Hoffer and Carr (15) reported that iron and other metallic compounds can accumulate in the internal tissue of the nodes from where other vascular bundles arise and extend into the roots, leaves and husks of the ears. They found that root and stalk rot was increased by the application of aluminum to the soil but in most cases the effect of lime or potassium reduced the root and stalk rot severity. Foley (13) obtained greatly increased severity of internal rot, stalk breakage and premature dying with a high nitrogen-potassium ratio (200:0); however, a low nitrogen-potassium ratio (0:200) reduced the amount of rot and lodging. Addition of phosphorus to high nitrogen-potassium levels did not affect the development of internal rot and amount of stalk lodging but it increased the amount of premature dying. Edwards (10) found that in sand cultures the levels of nitrogen, potassium, and phosphorus had no significant effect on seedling blight of corn.

Thayer and Williams (37) reported that an increase in nitrogen or a decrease in phosphorus resulted in a high stalk rot incidence whereas an increase of potassium had no effect. The effect of nitrogen and potassium on the development of stalk rot was found to be interrelated so that the effect of one was dependent on the level of the other. At low potassium levels, different nitrogen levels had no influence on stalk rot development, but at medium and high levels of potassium, an increase in the nitrogen level increased stalk rot severity (28).

Roberts (30) reported the manner of growth of D. zeae in the corn stalks. He found that in two weeks following inoculations the second internode was necrotic and discoloration had occurred. Diplodia zeae was isolated from all the necrotic areas of the inoculate internode and from most of the necrotic bundles therein, but water soaked nodal tissue surrounding the discolored area was always found to be sterile. He also observed that in all instances of discolored pith, the intercellular spaces were filled with a dark brown substance. Necrosis within the vascular bundle was more abundent in the phloem than in the xylem. He also reported that the discoloration of the vascular tissue appeared in advance of mycelial growth. He suggested that in the infected areas, sieve tubes in the phloem and vessels in the xylem were plugged with a dark brown substance which appeared to be masses of fungal hyphae. Roberts concluded that the spread of fungus in the parenchymatous tissue was primarily intercellular at first, later premeating the cells. Passage through the nodes was restricted except through the vascular bundles or necrotic tissues. Lignified cells did not seem to prevent the penetration of D. zeae but slowed its progress.

DeTurk et al.(4) made a complete chemical analysis of the carbohydrates and total sugars of two single crosses, R4xHY and LanxR313, respectively resistant and susceptible to diplodia stalk rot and low temperatures in the fall. They found that the resistance of R4xHY was associated with high total carbohydrates and sugars, whereas the susceptibility of LanxR313 was associated with low carbohydrate concentration. They concluded that the percentage of total sugars in the corn stalks was related to the stalk injury caused by D. zeae or low temperatures.

Whitney and Mortimore (39) obtained an ether extract sap from corn stalks and found the extract to inhibit the growth of G. Fujikuroi and G. zeae in culture. They concluded that the reason why stalks of young maize plants were not attacked by these fungi was due to the prescence of an antifungal substance in those plants.

Melhus (25) reported that an ether extract of corn stalks reduced the mycelial growth of D. zeae in culture and delayed the blight in corn seedlings. The nature of the inhibitory substance was found to be a nonvolatile, stable organic compound.

Johann and Dickson (20) extracted a sap soluble substance that restricted the growth of D. zeae, G. zeae, and Nigrospora oryzae in culture from corn stalks. The presence of this substance was associated with the maturation of the plant and some lines produced more growth retarding substance than the others. The effect of the growth retarding substance was unaltered by artificial defoliation or prevention of pollination. The nature of the growth retarding substance was not determined. These workers concluded that physiological type of resistance was not necessarily associated with the morphological resistance.

Taylor (35) showed that the juice from the resistant stalks supported the growth of D. zeae better than did the juice from the susceptible stalks. The results obtained tended to oppose those obtained by Johann and Dickson (20).

Davis et al. (3) also made studies on the nature of the antifungal substance. They reported that the hot water extract of dry pith contained the substance that retarded the growth of D. zeae in culture. The hot water extracts of eight varieties were analyzed for sugars and total nitrogen, in order to explain the growth of the fungus in culture. A positive correlation was obtained between the growth organisms on ground stalk meal and the sucrose reserve in the stalks.

Pappelis (29) reported that resistance to stalk rot was associated with high water contents in the stalks. He observed that the pith in susceptible stalks tended to have a whitish appearance as the result of air vacuoles in the cells. This could be attributed to the difference in water content of the internode pith of a susceptible and of a resistant stalk. Since the total sugars and sucrose were highly correlated with total dissolved solids on a volume basis, and as there was no correlation between rot development and percent total dissolved solids, he suggested no correlation between soluble carbohydrate contents and stalk rot development. Pappelis believed that living tissue of the stalk on continously released substances that accumulated to toxic levels to certain fungi. He was of the opinion that these substances were phenolic in nature and on oxidation and condensation resulted in pigmentation, which would account for the discoloration of the tissue.

Andrew (1), Jugenheimer (21), Hooker (17), and Sprague (34) have reported that the nature of resistance to stalk rot appears to be inherited in a typically quantitative fashion and the hybrids are resistant usually in proportion to the number of resistant inbred lines used in their synthesis. Jugenheimer concluded that the resistance to D. zeae appears to be inherited as partially dominant, but, however, he felt that the nature of resistance was complex and due to many factors. Zuber et al. (40) reported a correlation of stalk rot development in the parents, F_1 and F_2 generations, and backcrosses, for D. zeae and G. zeae. In order to study the mode of inheritance of resistance, Sprague (34) inoculated with D. zeae a resistant and a susceptible inbred line, their F_1 and F_2 crosses and backcrosses. He concluded that the F_1 cross was intermediate in reaction between the parents but there was a slight tendency for the reaction to be near that of the resistant line. The F_2 cross was more susceptible than the F_1 cross but the two backcrosses tended to resemble their respective parents.

MATERIALS AND METHODS

Source of Fungi

Isolations were made from the previous year's diseased corn stalks. The infected portion of the stalks were first surface disinfected with a 1:1000 mercuric chloride solution. The stalks were split lengthwise with a flame sterilized knife. The exposed pith was sliced with a flamed scalpel and small pieces of pith were transferred to a sterile potato-dextrose agar medium (PDA) in Petri-plates. Later, hyphal tip isolations of various organisms growing from the infected pith were made on PDA plates. The isolates retained were *Diplodia zeae*, *Gibberella zeae*, *Fusarium moniliforme*, and *Nigrospora oryzae*. The cultures of *D. zeae* and *G. zeae* were maintained on PDA slaints.

Source of Corn Seeds

Seeds of 80 corn inbred lines and of three-way top cross hybrids involving these inbred lines were kindly supplied by Dr. C. M. Nagel, Plant Pathology Department, South Dakota State College. The inbred lines were developed from the variety Fulton's Yellow Dent in connection with a search for root-rot resistant lines. The three-way hybrids were produced by crossing the inbred lines with a single cross SD 26 x B 8 as pollen parent. The seeds of 68 other inbred lines were obtained through the courtesy of Dr. D. B. Shank, Agronomy Department, South Dakota State College. These inbred lines included those developed by him at the South Dakota Agricultural Experiment Station and by other investigators at other experiment stations in the north central region of the United States.

All seeds were treated with captan prior to planting.

Field Plot Arrangement

Field plantings of corn were made in triplicated randomized blocks. Each plot contained 8 to 10 plants, spaced 12 inches within and 42 inches between rows. Overhead irrigation was supplied on two occasions to maintain the plants in a proper state of growth.

Preparation of Inoculum

The isolates of *D. zeae* and *G. zeae* were grown in large flat-sided bottles on a carrot agar medium and on PDA respectively for a period of two weeks at $65^\circ - 70^\circ$ F. Concentrated inocula were prepared by grinding each culture separately for approximately two minutes in 200 ml of distilled water in a Waring Blendor. Each inoculum was added to 300 ml of distilled water to bring its dilution to 500 ml. The inocula consisting of water spore suspensions of *D. zeae* and *G. zeae* were used separately in all inoculations.

Inoculation Techniques

Plants were inoculated at silking with a water spore suspension of the culture. In each plot of 8 to 10 plants, 3 plants were inoculated with *D. zeae* and 3 plants with *G. zeae*. The remaining plants varying from two to four were inoculated with sterilized water. Holes approximately 2 mm in diameter were made in each stalk in the center of the second and fourth internodes, with a punch, made of a common 8 penny nail fixed to a handle. About 1 to 2 ml of inoculum was injected into the holes with a hypodermic syringe at an angle of 45°. One important feature of this syringe was that the needle had holes on the sides rather than at the end. Therefore, the holes seldom became clogged. After the inoculations, the cites were covered with petrolatum to prevent further entrance of microorganisms.

Disease Evaluation

Data on stalk rot development was collected four weeks after inoculations. Stalks were split longitudinally, and the extent of discoloration was estimated. The discolored area was considered to represent the area infected by the pathogen. The grading system was based on the Weber-Fechner Law which states that visual acuity depends on the logarithm of intensity of the stimulus (19). A discoloration index value of 0 to 10 was used to classify the amount of discoloration (Figures 1 and 2). The percentage of internode discolored was derived from the following relationship:

Discoloration Index	Percent Internode Discolored
0	None
1	0 - 3
2	4 - 6
3	7 - 12
4	13 - 25
5	26 - 50
6	51 - 75
7	76 - 87

8	88 - 94
9	95 - 97
10	97 - 100, including nodal discoloration of adjacent internodes.

Disease Data Analysis

The stalk rot index value of a corn line in a replication was obtained by averaging at most six such values from at most three plants injected in two separate internodes with water, G. zeae, or D. zeae. The mean value so obtained for the corn lines in each of three replications was used for the analysis of variance of the data from these lines. The mean value over three replications for each line was used to obtain correlation coefficients in stalk rot development between kinds of injections and between inbred lines and their top crosses so injected. For information purposes, the mean values over three replications was converted to percent internodal area rotted and this percentage along with the corresponding mean disease index value is listed for each of the corn lines presented in the various tables to follow.

Fungus Re-isolation

A composite sample of inoculated stalks was brought to the laboratory and D. zeae and G. zeae were re-isolated from the discolored areas. From check plants, mainly Fusarium spp. and saprophytes were isolated.

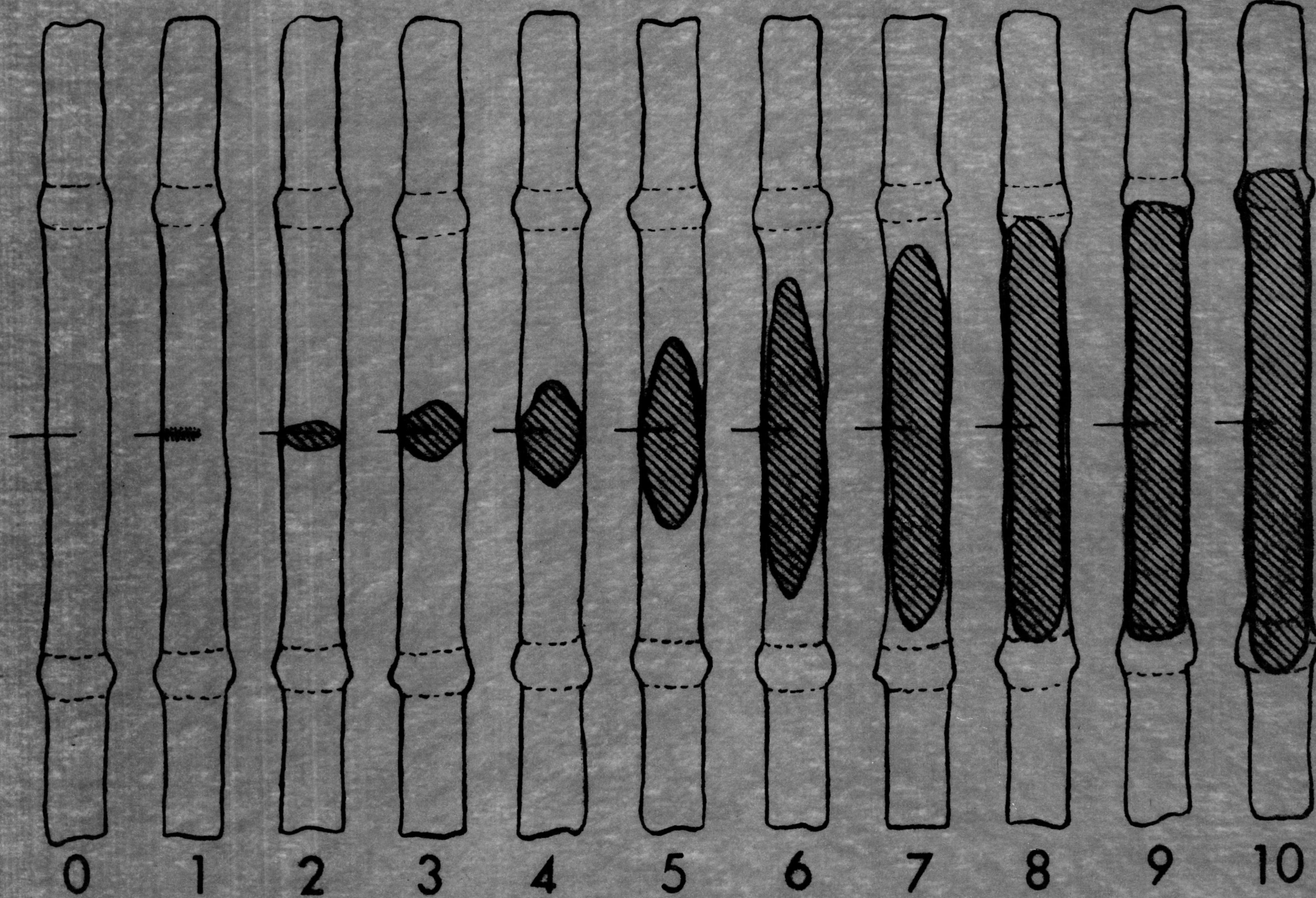

Figure 1. Diagrammatic sketch of stalk rot disease indices.

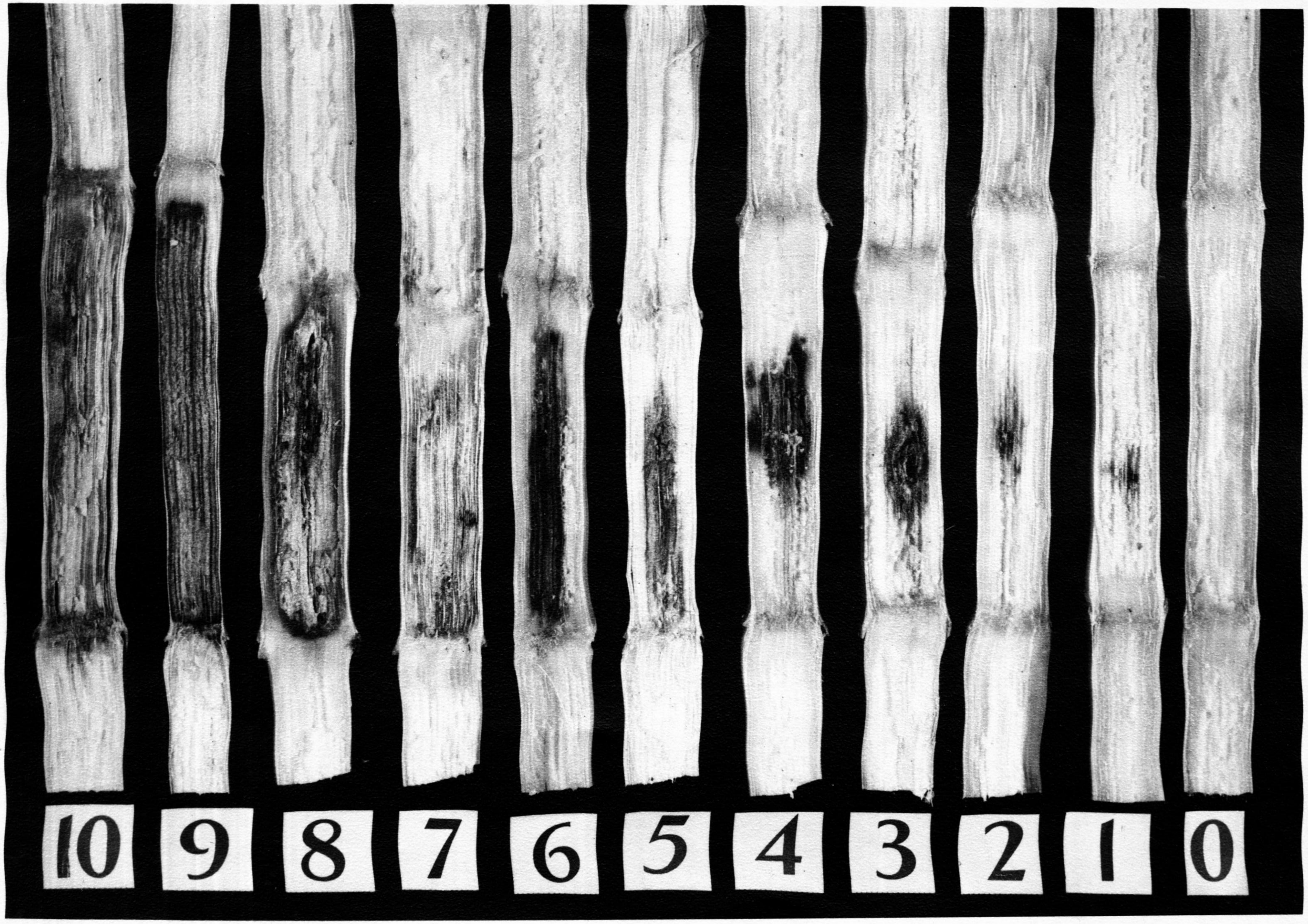

Figure 2. Stalks representing disease indices

EXPERIMENTAL RESULTS

Comparison of Stalk Rot Indices from Second and Fourth Internodes.

As mentioned under Methods, each plant was injected with water, *G. zeae* or *D. zeae* at the second and fourth internodes. The stalk rot disease index values obtained from these internodes among Plant Pathology Department Inbred lines were significantly correlated ($P > 0.05$) with one another to the extent of +0.223 for water injection, +0.542 for *G. zeae* injection and +0.444 for *D. zeae* injection. The values from the Plant Pathology Department inbred lines top crossed with SD26 x B8 also were significantly correlated with one another to the extent of +0.242, +0.409 and +0.224, respectively. Since the variance of the stalk rot disease index values between plants within a replication was not used in the analysis of the data, averaging the disease index values for each plot was considered feasible.

Stalk Rotting Evaluations in Plant Pathology Department Inbred Lines.

The stalk rot indices of the Plant Pathology Department inbred lines injected with water, *G. zeae* and *D. zeae* and the corresponding percentage of internodal areas rotted are presented in Table I. In that table the 80 inbred lines are arranged in ascending order of stalk rot indices resulting from water injections. The order was selected after a study of the data so that one might compare better the stalk rot indices derived from *G. zeae* and *D. zeae* injections with that derived from water injection. The average least difference between

Table I. Stalk Rot Disease Index and Percent of Internodal Area Discolored Among Plant Pathology Department Inbred Lines of Dent Corn. Plants Field Injected with Water, *Gibberella zeae* and *Diplodia zeae*. Brookings, 1960

	Water		*G. zeae*		*D. zeae*	
LINE[1] NO.	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored
697	1.1	2	2.7	8	2.8	8
598	1.2	2	2.7	7	4.5	26
636	1.2	2	3.2	10	3.2	10
690	1.2	2	3.4	12	5.1	38
637	1.2	2	3.6	15	6.4	72
696	1.2	2	3.8	16	3.9	17
404	1.2	2	5.7	55	5.2	40
645	1.4	3	2.8	65	6.1	61
688	1.4	3	3.8	16	5.3	42
703	1.4	3	4.2	20	8.0	90
625	1.4	3	4.9	32	4.5	26
600	1.5	3	3.2	10	3.9	17
640	1.5	3	3.5	12	6.0	60
647	1.5	3	5.3	42	7.2	83
606	1.7	4	2.9	7	3.5	15
522	1.7	4	3.0	9	1.3	2
661	1.7	4	3.1	10	3.9	17
669	1.7	4	3.8	16	4.9	32
666	1.8	4	2.8	8	5.0	36
532	1.8	4	3.3	12	3.2	10
504	1.8	4	3.5	13	3.8	16
551	1.8	4	3.6	15	4.2	20
653	1.8	4	3.6	15	6.2	70
493	1.8	4	3.8	16	7.1	71
428	1.8	4	4.2	20	5.1	38
453	1.8	4	4.5	25	2.5	6
482	1.9	4	3.1	10	4.8	30
439	1.9	4	3.4	12	3.5	12
445	1.9	4	3.4	12	4.6	27
572	1.9	4	3.4	12	7.1	82
496	1.9	4	3.7	15	6.9	80
692	1.9	4	4.2	20	4.8	30
706	1.9	4	3.0	9	5.5	50
440	2.0	4	3.7	15	3.8	16
642	2.0	4	3.7	15	7.0	80
601	2.0	4	3.9	17	5.3	42
686	2.0	4	5.1	38	5.8	58

Table I. (Continued)

LINE[1] NO.	Water		G. zeae		D. zeae	
	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored
680	2.1	5	3.6	15	6.4	72
429	2.1	5	3.7	15	4.6	27
582	2.1	5	3.9	17	5.3	42
416	2.1	5	4.0	18	4.2	20
575	2.1	5	4.2	20	5.0	36
634	2.1	5	5.3	42	3.9	17
452	2.2	5	3.0	9	5.8	58
705	2.2	5	3.1	10	7.4	85
436	2.2	5	3.3	12	5.0	36
495	2.2	5	3.4	12	6.6	76
424	2.3	5	4.9	32	4.8	30
417	2.4	6	3.0	9	4.5	26
435	2.4	6	3.4	12	4.1	19
584	2.4	6	3.8	16	4.7	28
587	2.4	6	4.2	20	4.6	27
552	2.4	6	5.8	60	4.4	25
567	2.5	6	3.8	16	4.0	18
659	2.5	6	5.3	42	5.3	42
410	2.6	7	4.2	20	7.7	87
510	2.6	7	4.6	27	6.0	60
412	2.7	7	3.2	10	6.4	72
638	2.7	7	3.2	10	7.1	82
536	2.7	7	3.3	12	4.7	28
618	2.7	7	3.4	12	5.8	58
420	2.7	7	3.8	16	4.4	25
484	2.8	8	3.7	15	6.8	78
408	2.8	8	4.0	18	7.2	83
644	2.9	8	3.1	10	8.1	91
639	2.9	8	3.5	12	4.3	20
508	2.9	8	6.1	65	5.9	60
458	3.0	9	3.9	17	4.9	32
415	3.1	10	3.3	12	6.1	65
491	3.3	12	3.8	16	6.1	65
459	3.7	15	5.2	40	6.1	65
632	3.7	15	5.3	42	6.5	75
527	4.0	18	5.5	50	7.8	88
573	4.1	19	6.1	60	5.0	36
542	5.0	36	5.7	55	6.8	78
505	5.1	38	5.8	58	6.2	70
627	5.2	40	4.8	30	5.7	55

Table I. (Continued)

LINE[1] NO.	Water		G. zeae		D. zeae	
	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored
537	5.5	50	4.3	20	5.7	55
630	7.3	83	7.3	83	7.1	82
545	8.3	92	7.6	87	7.8	88
Mean	2.5		4.0		5.3	
L.S.D.[2]	1.91		1.64		1.99	

[1] Inbred lines arranged in ascending order of stalk rot indices derived from water injections.

[2] At 5 percent probability.

index values of two corn lines necessary at the 5 percent level of probability is given at the bottom of the table for each kind of injection.

As may be seen from the table the mean stalk rot index value from water injection was 2.5, from G. zeae injection was 4.0 and from D. zeae injection 5.3. The range of stalk rot index values was 1.1 to 8.3 for water injection, 2.7 to 7.6 for G. zeae injection and 1.3 to 8.1 for D. zeae injection. The corresponding standard deviation values were 1.3, 1.0 and 1.4.

The analysis of variance of the stalk rot disease index values for the 80 inbred lines is presented in Table II. The variance of these values was highly significant for each of water, G. zeae and D. zeae injections. The variance due to replications was not significant.

Table II. The Analysis of Variance of Stalk Rot Disease Indices of Eighty Plant Pathology Department Inbred Lines of Dent Corn Injected with Water, *Gibberella zeae* and *Diplodia zeae*

Source of Variance	DF	Water MS	Water F	G. zeae MS	G. zeae F	D. zeae MS	D. zeae F
Replications	2	1.13	.81	2.03	1.99	2.70	1.79
Lines	79	4.89	3.51**	3.12	3.05**	5.68	3.77**
Error	158	1.39		1.02		1.51	

** Significant at the 1 percent level

On further inspection of the data in Table I, one may see that the ascending order of stalk rot indices from water injections was paralleled by an ascending order of stalk rot indices from G. zeae and D.

zeae injections. The extent of this parallelism may be derived from the following calculated correlation coefficients, all above the one percent level of probability: +0.680 between water injection and G. zeae injection, +0.397 between water injection and D. zeae injection and +0.302 between G. zeae and D. zeae injection. Since the size of these coefficients reflect the degree of parallelism between the indices, one may interpret that the stalk rot indices derived from G. zeae injection in some way may have been related more to the stalk rot indices derived from water injection than to the stalk rot indices derived from D. zeae injection. In this fashion also one may interpret that the relationship between G. zeae and D. zeae stalk rot indices was less than that between G. zeae and water stalk rot indices. This seemed to be borne out when the stalk rot index values from water injections was subtracted from the corresponding stalk rot index values from G. zeae and D. zeae injection yielding a correlation coefficient of +0.215 between G. zeae and D. zeae stalk rot indices above the five percent level of probability. One reason for this apparent decline in parallelism may have been that microorganisms, principally Fusarium spp. mentioned under Methods, induced the rot in water injected plants and contributed more to rot production in plants injected with G. zeae than in those injected with D. zeae.

A comparison of the extent of stalk rotting in the 80 inbred lines injected with water, G. zeae and D. zeae may be seen best from the frequencies of such lines exhibiting various amounts of rot. Such frequencies are shown in Table III and IV where, respectively, the

Table III. Frequency Distribution of Eighty Plant Pathology Department Inbred Lines over Stalk Rot Disease Index Classes Derived From *Diplodia zeae*, *Gibberella zeae* and Water Injection

	Stalk Rot Disease Index Class														
Injections	1.0 1.4	1.5 1.9	2.0 2.4	2.5 2.9	3.0 3.4	3.5 3.9	4.0 4.4	4.5 4.9	5.0 5.4	5.5 5.9	6.0 6.4	6.5 6.9	7.0 7.4	7.5 7.9	8.0 8.4
D. zeae	1			2	2	8	7	13	11	7	11	5	8	3	2
G. zeae				5	23	23	9	5	6	5	2		1	1	
Water	10	20	23	14	3	2	2		3	1			1		1

Standard deviation for *D. zeae* 1.3, *G. zeae* 1.0 and water 1.4

Table IV. Frequency Distribution of Eighty Plant Pathology Department Inbred Lines over Percentage of Internodal Area Rotted Classes Derived From *Diplodia zeae*, *Gibberella zeae* and Water Injections

	Percent of Internodal Area Rotted Classes									
Injections	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
D. zeae	5	13	13	9	5	8	6	9	11	1
G. zeae	17	44	3	4	5	4	1		2	
Water	69	5		3	1				1	1

extent of rot is classified according to stalk rot index values and percentages of internode rotted. In Table III the frequency distribution pattern of inbred lines injected with water approached a normal curve skewed to the right with a sharp hump in the range of 1.5 to 2.4 disease index values. The pattern of lines injected with G. zeae also approached a normal curve skewed to the right but with a sharp hump in the range of 3.0 to 3.9 disease index values. The pattern of lines injected with D. zeae approached a flattened normal curve with the hump portion of the curve extending from about 3.5 to 7.4 disease index values. As mentioned above, the standard deviation values for these distributions respectively were 1.3, 1.0 and 1.4.

Shown in Table IV are the same distributions classified according to the percentage of internode rotted. In these distributions the humps of the skewed normal curves for inbred lines injected with water and with G. zeae were shifted to the left while the curve for the lines injected with D. zeae was flattened to such an extent that the frequencies of inbred lines were fairly evenly distributed over the range of 1 to 90 percent of the internodal area rotted. The distribution patterns of the lines injected with water and G. zeae in this classification thus became even more strikingly similar to one another and different from that of lines injected with D. zeae.

The reason for the skewed portion of the normal curves for inbred lines injected with water for G. zeae was explored by examining the stalk rot index values of the lines comprising that portion of the curves. As might have been suspected, the inbred lines comprising the tail portion of the curves were principally at the bottom of the list of lines shown in Table I. This situation was so for the lines injected with water and for the most part so with lines injected with *G. zeae* and *D. zeae*. A reason for this may be that some of the inbred lines, especially those numbered 545 and 630, may have been naturally rotted to such an extent that the rot confounded the rot index ratings ascribable to each of the three injections.

In view of the above, *D. zeae* may be considered to have been more discriminating of lines for stalk rot reaction than was *G. zeae*. Stated another way, *G. zeae* may be considered to have been a much weaker pathogen than *D. zeae* either for inherent reasons in the pathogen or host, or for inadequacy in the injection method. At the moment neither of these possibilities can be accounted. The response to *D. zeae* was such that one could fairly confidently choose inbred lines for resistance or susceptibility by applying the usual measure of so many standard deviations from the mean.

Stalk Rotting Evaluations of Plant Pathology Department Inbred Lines Top Crossed with a Single Cross.

Stalk rotting evaluations of inbred lines usually is problematic for the reason that the lines are heterogeneous in rate of development, size, chemical composition and susceptibility to various climatic and microbiological stresses. For that reason the inbred lines might better be evaluated for their stalk rotting tendencies when in hybrid combination with another inbred line or with a single cross.

In that situation the products would be less heterogeneous in the characters mentioned and the genetic components of the lines in the product would be diluted by a factor of one-half. Although the dilution of the genetic components of the lines may be considered disadvantageous to a proper evaluation of those lines as such, the evaluation of the lines in hybrid combination would more nearly approach the practical hybrid situation in the field if a suitable partner could be found that would help differentiate the stalk rotting tendencies of those lines. Such a partner could be one that was resistant, intermediate or susceptible to stalk rotting, in which case the inbred lines in hybrid combination would respectively tend to increase and/or reduce the resistance of the product according to the genetic factors they had for stalk rotting.

For the present study, the Plant Pathology Department inbred lines were top crossed with a single cross SD26 x B8, where inbred line SD26 was extremely susceptible to _D. zeae_ stalk rot and inbred line B8 was moderately susceptible. The single cross itself was susceptible to _D. zeae_ stalk rot and resistant to _G. zeae_ stalk rot. The three-way hybrids so produced were injected with water, _G. zeae_ and _D. zeae_ as with the inbred lines discussed above.

The stalk rot disease indices and the percent of internodal areas rotted in 89 three-way hybrids, which included hybrids of all the inbreds evaluated above, are listed in Table V in ascending order of stalk rot disease indices of hybrids injected with water. The stalk rot disease indices of hybrids injected with water ranged from 1.6 to 4.9, those injected with _G. zeae_ ranged from 2.5 to 5.4, and

Table V. Stalk Rot Disease Index and Percent of Internodal Area Discolored Among Eighty-nine Plant Pathology Department Inbred Lines Top Crossed With the Single Cross SD26 x B8. Plants Field Injected With Water, *Gibberella zeae* and *Diplodia zeae* Brookings, 1960

Inbred Line[1] Number Topcrossed With SD26 x B8	Water		*G. zeae*		*D. zeae*	
	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored
637	1.6	4	2.9	8	6.2	70
640	1.7	4	2.9	8	5.7	55
435	1.7	4	3.0	9	5.5	50
495	1.7	4	4.2	20	6.5	75
545	1.8	4	4.1	19	6.4	72
567	1.8	4	4.3	20	5.9	60
551	1.8	4	4.9	32	5.7	55
639	1.9	4	2.5	6	5.2	40
575	1.9	4	2.8	8	4.8	30
482	1.9	4	3.4	12	6.6	76
584	1.9	4	3.8	16	4.7	27
496	1.9	4	4.1	19	7.2	83
606	2.0	4	2.8	8	6.0	60
644	2.0	4	3.6	15	6.5	75
483	2.0	4	4.1	19	5.2	40
636	2.1	5	2.7	7	4.7	27
659	2.1	5	2.7	7	4.8	30
647	2.1	5	3.5	12	6.0	60
598	2.1	5	3.9	17	6.5	75
627	2.1	5	4.2	20	5.0	36
537	2.1	5	4.5	26	6.2	70
645	2.2	5	3.1	10	6.6	76
505	2.2	5	4.4	25	6.6	76
424	2.2	5	4.6	27	7.1	82
638	2.3	5	2.5	6	5.5	50
452	2.3	5	3.2	10	5.1	38
630	2.3	5	4.1	19	5.7	55
404	2.3	5	4.2	20	5.4	46
428	2.3	5	4.2	20	5.6	52
618	2.4	6	3.3	12	5.9	60
657	2.4	6	3.4	12	5.6	52
692	2.4	6	3.5	12	6.6	76
633	2.4	6	3.7	15	5.7	55
484	2.4	6	3.8	16	6.2	70
429	2.4	6	3.9	17	6.7	77
445	2.5	6	2.8	8	5.6	52

Table V. (Continued)

Inbred Line[1] Number Topcrossed With SD26 x B8	Water		*G. zeae*		*D. zeae*	
	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored
634	2.5	6	3.8	16	4.1	19
697	2.5	6	3.9	17	4.4	25
459	2.5	6	5.4	46	5.2	40
686	2.6	7	3.7	15	5.8	58
680	2.6	7	3.7	15	6.1	65
430	2.6	7	4.2	20	6.1	65
609	2.6	7	4.3	20	6.5	75
440	2.6	7	4.9	32	6.5	75
663	2.7	7	2.8	8	5.7	58
492	2.7	7	3.2	10	6.0	60
504	2.7	7	3.4	12	6.7	77
669	2.7	7	4.0	18	5.2	40
416	2.8	8	3.6	15	8.2	92
572	2.8	8	3.9	17	6.5	75
653	2.8	8	4.5	26	6.2	70
703	2.8	8	4.5	26	6.2	70
642	2.9	8	3.4	12	5.0	36
625	2.9	8	4.5	26	7.1	82
632	2.9	8	4.8	30	6.7	77
436	3.0	9	3.4	12	6.7	77
688	3.0	9	3.9	17	6.2	70
493	3.0	9	4.5	25	5.5	50
476	3.1	10	3.4	12	5.9	60
674	3.1	10	3.7	15	5.8	58
661	3.1	10	3.9	17	5.9	60
439	3.1	10	4.1	19	4.9	32
532	3.1	10	4.1	19	5.3	42
552	3.1	10	4.8	30	5.6	52
705	3.1	10	4.8	30	8.2	92
542	3.1	10	5.2	40	6.9	79
453	3.2	10	3.5	12	5.0	36
666	3.2	10	3.7	15	5.1	38
425	3.2	10	3.7	15	6.4	72
696	3.2	10	4.2	20	5.2	40
564	3.2	10	5.4	46	6.3	71
587	3.3	12	3.7	15	4.8	30
408	3.3	12	4.1	19	5.8	58
491	3.5	12	2.4	6	5.8	58
658	3.5	12	3.3	12	7.3	84

Table V. (Continued)

Inbred Line[1] Number Topcrossed With SD26 x B8	Water		G. zeae		D. zeae	
	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored
706	3.5	12	4.1	19	7.2	83
600	3.5	12	4.9	32	6.3	71
690	3.7	15	3.9	17	5.0	36
415	3.7	15	4.1	19	6.5	75
582	3.9	17	3.7	15	4.8	30
412	3.9	17	4.0	18	6.5	75
420	3.9	17	4.1	19	6.3	71
508	3.9	17	5.3	42	6.7	77
527	4.0	18	5.4	46	6.7	77
537	4.2	20	3.7	15	5.7	55
684	4.5	26	3.8	16	6.3	71
410	4.6	27	4.9	32	7.1	82
417	4.7	28	3.2	10	6.8	78
510	4.9	32	5.3	42	7.0	80
Mean	2.8		3.9		6.0	
L.S.D.[2]	.57		1.37		.52	

[1] Three-way hybrids in ascending order of stalk rot index derived from water injections.

[2] At 5 percent probability.

those injected with D. zeae ranged from 4.1 to 8.2. The corresponding means were 2.8, 3.9 and 6.0 and the corresponding standard deviations were 0.7, 0.7 and 0.8. The means essentially were the same as those for the 80 inbred lines listed in Table I.

The analysis of variance of the stalk rot disease index values is presented in Table VI. The variance between hybrids injected with water, G. zeae and D. zeae was highly significant in all instances. The variance between replications had less than a five percent level of probability in plants injected with D. zeae, and was not significant in plants injected with water or G. zeae.

Table VI. The Analysis of Variance of Stalk Rot Disease Indices of Eighty-nine Plant Pathology Department Inbred Lines Top Crossed With a Single Cross SD26 x B8. Plants Field Injected With Water, Gibberella zeae and Diplodia zeae.

Source of Variance	DF	Water MS	Water F	G. zeae MS	G. zeae F	D. zeae MS	D. zeae F
Replications	2	.58	.45	1.45	2.00	3.41	3.24*
Lines	88	1.92	1.51**	2.00	2.70**	1.89	1.80**
Error	176	1.27		.72		1.05	

** Significant at the 1 percent level
* Significant at the 5 percent level

The extent of concordance between stalk rot disease indices in hybrids injected with water and those injected with G. zeae and D. zeae may be noted from a visual inspection of the data in Table V. From such an inspection one may note that the concordance was not as close as it was for similar data of inbred lines listed in Table I.

The calculated correlation coefficients obtained were +0.205 between three-way hybrids injected with water and those injected with G. zeae, +0.255 between hybrids injected with water and those injected with D. zeae, and +0.411 between hybrids injected with G. zeae and those injected with D. zeae. The first two correlation coefficients had a probability value of less than five percent while the third had a probability value of less than one percent. The extent of concordance of stalk rot disease indices of hybrids injected with water with those injected with G. zeae or D. zeae was not as close as it was with the inbred lines listed in Table I. One reason for this may have been that the internal stalk environment in hybrids was less heterogeneous than in inbreds for the development of contaminating Fusarium spp. and other microorganisms that accompanied the injection of water into the stalks. Subtracting the stalk rot disease indices for water injections from those for G. zeae and D. zeae injections yielded a highly significant correlation coefficient of +0.454 between indices for the two fungi. This value essentially was no different than that obtained when the subtraction was not made. The unchanged situation of the correlation coefficient value was in sharp contrast to a deteriorated correlation coefficient value obtained when a similar subtraction was made in inbred lines.

The extent of the concordance of the stalk rot disease index values between inbred lines and their hybrids obtained from water, G. zeae and D. zeae injection may be seen in the correlation coefficient values listed in Table VII. The correlation coefficient value between inbred lines and their hybrids following water injection was very low and not significant, as may have been suspected from the above. When the disease index values for water were subtracted from the values for G. zeae and D. zeae, the resulting correlation coefficient between inbreds and their hybrids for each pathogen was also low and not significant. However, when the index values for water were not subtracted then highly significant, moderately high correlation coefficients were obtained with both pathogens. A reason for this difference in response may be that subtraction of water index values over stresses the importance in inbred lines that this rot made to those ascribed to G. zeae and D. zeae. Hence subtraction of such index values from G. zeae and D. zeae indices would appear to be unwarranted in inbreds as well as in hybrids.

Table VII. Correlation Coefficients Between Eighty Plant Pathology Department Inbred Lines and Their Hybrids Based on Stalk Rot Disease Indices Derived From Water, Gibberella zeae and Diplodia zeae Injections in Stalks

Injections	Correlation (r value)
D. zeae	+0.332**
G. zeae	+0.404**
Water	+0.062
D. zeae[1]	+0.181
G. zeae[1]	+0.123

** Significant at the 1 percent level
[1] After subtraction of stalk rot disease indices derived from water injections

A comparison of the amount of stalk rotting in the 89 three-way hybrids injected with water, G. zeae and D. zeae may be derived from

Table VIII and Table IX in the frequency distribution patterns of those hybrids classified according to disease index values and percentage of internodal area rotted. The frequency distribution patterns of the hybrids classified according to disease index values (Table VIII) approached normal type curves for each kind of injection, with none of the curves being unduly skewed or flattened as in the case of inbred lines, shown in Table III. The relative location of the curves on the scale of disease indices were essentially the same as with those of inbred lines. The distribution pattern of hybrids injected with water was humped principally in the range 2.0 to 3.4 disease index values, that injected with *G. zeae* was humped principally in the range 3.5 to 4.4 disease index values, and that injected with *D. zeae* was humped in the range 5.5 to 6.9 disease index values. The standard deviations of each of these distributions was 0.7, 0.7 and 0.8, respectively. There was more overlapping in distribution patterns for hybrids injected with water and *G. zeae* than with hybrids injected with *D. zeae*.

The frequency distribution of hybrids classified according to percent of internodal area rotted (Table IX) was J-shaped when injected with water, near normal when injected with *G. zeae* and doubly or triply peaked when injected with *D. zeae*. The greatest frequency of hybrids injected with water fell in the class of 1 to 10 percent of the internodal area rotted, those injected with *G. zeae* fell in the class of 11 to 20 percent, and those injected with *D. zeae* fell in the classes of 51 to 60 percent, 71 to 80 percent and possibly 31 to 40 percent. As

Table VIII. Frequency Distribution of Eighty-nine Plant Pathology Department Three-way Hybrids over Stalk Rot Disease Index Classes Derived from *Diplodia zeae*, *Gibberella zeae* and Water Injections

Injections	Stalk Rot Disease Index Class														
	1.0 1.4	1.5 1.9	2.0 2.4	2.5 2.9	3.0 3.4	3.5 3.9	4.0 4.4	4.5 4.9	5.0 5.4	5.5 5.9	6.0 6.4	6.5 6.9	7.0 7.4	7.5 7.9	8.0 8.4
D. zeae							2	7	13	21	17	20	7		2
G. zeae			1	10	13	25	21	13	6						
Water		12	24	20	18	10	2	3							

Standard deviation for *D. zeae* 0.8, *G. zeae* 0.7 and water 0.7

Table IX. Frequency Distribution of Eighty-nine Plant Pathology Department Three-way Hybrids over Percentage of Internodal Area Rotted Classes Derived from *Diplodia zeae*, *Gibberella zeae* and Water Injections

Injections	Percent of Internodal Area Rotted Class									
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
D. zeae		1	7	12	5	21	8	27	6	2
G. zeae	16	54	10	4	5					
Water	71	14	3	1						

suggested for inbred lines, the standard deviation value may be useful as a measure in normal distributions to aid in the selection of resistant or susceptible hybrids for appropriate inbred lines.

Stalk Rotting Evaluations In Agronomy Department Inbred Lines

Sixty-eight inbred lines from the Agronomy Department were injected with water, *G. zeae* and *D. zeae* and the resulting stalk rot disease indices and percentages of internodal areas rotted are listed in Table X. As before, the inbred lines are arranged in ascending order of stalk rot disease indices for water injection.

As may be seen from the Table, the range of stalk rot disease indices of lines injected with water was 1.2 to 8.2, of inbred lines injected with *G. zeae* 1.8 to 9.4, and of inbred lines injected with *D. zeae* 2.6 to 9.6. The corresponding mean values were 3.0, 4.8 and 7.0. The values were higher than those obtained from Plant Pathology Department inbred lines, especially from those injected with *D. zeae*. The corresponding average least differences between index values of two corn lines necessary at the 5 percent level of probability was 2.8, 2.4 and 2.0.

The analysis of variance of the stalk rot disease values for the 68 inbred lines is presented in Table XI. The variance of these values was highly significant for water, *G. zeae* and *D. zeae* injections. The variance due to replications in each of these instances was not significant.

As may be seen from Table X, the stalk rot disease indices from water and *G. zeae* injections paralleled one another more closely than

Table X. Stalk Rot Index and Percent of Internodal Area Discolored Among Agronomy Department Inbred Lines of Dent Corn. Plants Field Injected With Water, Gibberella zeae and Diplodia zeae Brookings, 1960

INBRED[1] LINE NO.	Water		G. zeae		D. zeae	
	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored
Oh 56A x Sk1	1.2	2	2.5	6	7.0	80
Oh 56A tr	1.2	2	2.6	7	2.6	7
Oh 56A x Sk2	1.2	2	3.2	10	5.4	46
A 90	1.2	2	3.8	16	4.8	30
Oh 56A tr	1.2	2	4.3	20	4.7	28
A 556	1.3	2	2.8	8	4.8	30
Oh 56A x Sk6	1.4	3	1.8	4	6.8	78
KI	1.4	3	2.9	8	2.8	8
Oh 56A (Sk)	1.4	3	3.2	10	6.3	71
Ms 1334	1.4	3	3.7	15	7.1	82
(5tr x 56tr) tr	1.4	3	4.6	26	8.7	94
Oh 56A x Sk3	1.5	3	2.4	6	4.2	20
ERa	1.5	3	3.4	12	2.9	8
Oh 56A x Ska	1.5	3	3.5	12	6.4	72
SD7 tr	1.7	4	3.7	15	7.5	85
ND 1334	1.7	4	3.8	16	6.8	78
ERb	1.7	4	4.8	30	6.6	76
Wf9	1.8	4	3.2	10	2.9	8
W 353B	1.8	4	4.2	20	6.0	60
ND 230	1.8	4	4.5	25	7.8	88
Oh 56A	1.9	4	2.7	7	2.8	8
ND 468	1.9	4	3.4	12	6.5	75
A 509	1.9	4	4.8	30	7.1	82

Table X. (Continued)

INBRED[1] LINE NO.	Water		G. zeae		D. zeae	
	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored
SD (Oh 56A tr x B8) tr	2.0	4	4.3	20	8.5	93
B8 (Gehu)	2.0	4	4.4	25	5.9	60
ND 475	2.0	4	5.2	40	9.2	96
W 37A	2.2	5	4.0	18	6.6	76
I 153R	2.2	5	5.0	36	6.5	75
A 498	2.2	5	6.2	70	7.6	85
Pa 703Y	2.3	5	2.4	6	4.4	25
B8	2.3	5	4.3	20	6.1	65
SD5 (Oh 56A)	2.4	6	3.7	15	7.6	86
ND 36	2.4	6	4.8	30	6.6	76
Pa R53	2.5	6	3.7	15	8.0	90
Pa 33	2.7	7	4.5	26	7.5	85
ND 203	2.7	7	5.9	60	7.1	82
ERc	2.8	8	3.3	12	6.9	79
(A231 x L317)	2.8	8	4.4	25	5.2	40
SD 48 (230)	2.8	8	5.5	50	7.0	80
SD5 tr	2.8	8	5.9	60	8.8	95
SD 5	2.8	8	6.0	60	8.6	94
SD 17	3.0	9	5.7	55	6.2	70
B8 (230) a	3.1	10	4.1	19	3.2	10
SD 26	3.3	12	5.1	38	8.9	95
Pa 32	3.3	12	7.4	85	7.3	84
W 103	3.4	12	3.8	16	6.8	78
B8 (Rnbw)	3.4	12	4.2	20	6.6	76
W 59M	3.4	12	4.7	28	5.7	55
(SD5 x SD7 tr) x 28 tr	3.7	15	2.5	6	5.2	40
SD r1	3.7	15	5.6	52	9.4	97
CMD 5	3.7	15	6.6	76	8.6	94

Table X. (Continued)

INBRED[1] LINE NO.	Water		*G. zeae*		*D. zeae*	
	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored	Stalk rot Index	Percent Internode Discolored
A 495	3.8	16	5.7	55	7.9	90
A 111	3.8	16	6.9	80	9.3	96
W-D	3.9	19	6.9	80	9.2	96
B8 (230) b	4.2	20	4.0	18	7.6	86
W 401	4.2	20	5.7	55	6.9	80
Ellis x Oh 43	4.3	20	6.2	70	7.2	83
SD 7	4.4	25	5.2	40	8.2	92
W 459	4.6	27	4.8	30	8.5	93
A 508	5.1	38	5.6	52	7.6	86
SD5 (420)	5.2	40	6.5	75	8.7	94
Mt 42K	5.3	42	6.3	71	8.3	92
P 36	5.5	50	6.6	76	9.6	98
ND 30	5.5	50	6.7	77	8.8	95
SD 48	5.8	58	7.1	82	8.8	95
SD5 (317)	6.7	77	6.3	71	8.1	91
SD 420 (Sk)	7.4	85	8.0	90	9.0	95
M 14	8.2	92	9.4	97	8.3	92
Mean	3.0		4.8		7.0	
L.S.D.[2]	2.76		2.45		2.05	

1 Inbred lines arranged in ascending order of stalk rot indices derived from water injections.
2 At 5 percent probability.

with those from D. zeae injections. However, the calculated correlation coefficients of stalk rot indices from water and G. zeae injections was +0.764, from water and D. zeae injections was +0.537, and from G. zeae and D. zeae injections was +0.667, all exceeding the 1 percent level of probability. The coefficients were higher than those obtained from the Plant Pathology Department inbred lines, especially in the comparisons involving D. zeae. Their relatively high value may have been the result of extreme susceptibility of many of the lines to different microorganisms, including those that were not purposefully injected. Subtracting the index values for water injections from those of G. zeae and D. zeae injections lowered the correlation coefficient between these pathogens only slightly to a value of +0.537, which was still highly significant.

Table XI. The Analysis of Variance of Stalk Rot Disease Indices of Sixty-eight Agronomy Department Inbred Lines of Dent Corn Injected with Water, *Gibberella zeae* and *Diplodia zeae*

Source of Variance	DF	Water		*G. zeae*		*D. zeae*	
		MS	F	MS	F	MS	F
Replications	2	0.76	0.26	0.50	0.22	1.13	0.70
Lines	67	7.70	2.64**	6.46	2.80**	9.68	6.01**
Error	134	2.91		2.30		1.16	

** Significant at the 1 percent level

The frequency distribution pattern of the 68 inbred lines classified according to stalk rot disease index values and percentages of internodal areas rotted, are presented in Table XII and Table XIII,

Table XII. Frequency Distributions of Sixty-eight Agronomy Department Inbred Lines over Stalk Rot Disease Index Classes Derived from *Diplodia zeae*, *Gibberella zeae* and Water Injections

Injections	Stalk Rot Disease Index Class																	
	1.0 1.4	1.5 1.9	2.0 2.4	2.5 2.9	3.0 3.4	3.5 3.9	4.0 4.4	4.5 4.9	5.0 5.4	5.5 5.9	6.0 6.4	6.5 6.9	7.0 7.4	7.5 7.9	8.0 8.4	8.5 8.9	9.0 9.4	9.5 9.9
D. zeae				5	1		2	3	3	2	5	11	8	7	5	10	5	1
G. zeae		1	2	6	6	8	10	8	4	8	5	6	2		1		1	
Water	11	12	10	8	7	6	4	1	3	3		1	1		1			

Standard deviations for *D. zeae* 1.8, *G. zeae* 1.5 and water 1.6

Table XIII. Frequency Distributions of Sixty-eight Agronomy Department Inbred Lines over Percentage of Internodal Area Rotted Classes Derived from _Diplodia zeae_, _Gibberella zeae_ and Water Injections

	Percent Internodal Area Rotted Classes									
Injections	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
D. zeae		1	7	12	5	21	8	27	6	2
G. zeae	16	54	10	4	5					
Water	71	14	3	1						

respectively. As may be seen from the frequency distribution patterns classified according to stalk rot index values in Table XII, the normal curve pattern for inbred lines injected with water was skewed more to the right than for the Plant Pathology Department inbred lines shown in Table III. The pattern for lines injected with G. zeae was less peaked than for Plant Pathology Department inbred lines and consequently it was more spread out than for those lines. The same spreading was also apparent for the D. zeae pattern. Hence a considerable overlapping of distributions for the three situations was apparent.

The frequency distribution pattern of the lines classified according to the percentage of internodal area rotted (Table XIII) was such that a considerable overlapping of distribution was present. In two instances the distribution patterns approached a J-shaped curve, such that the upright portion of the J was situated at the extreme left of the table for water injections and to the extreme right of the table for D. zeae injections. The distribution pattern for G. zeae injection approached a near normal curve skewed markedly to the right.

DISCUSSION

As outlined in the introductory part of this thesis the purpose of the study was to evaluate the stalk rotting propensities of dent corn inbred lines developed by the Plant Pathology Department of the South Dakota Agricultural Experiment Station and of those developed or acquired from other sources by the Agronomy Department of the same station. In part of that evaluation the inbred lines developed by the Plant Pathology Department were also tested as hybrids in combination with the single cross SD26 x B8 susceptible to *D. zeae* stalk rot and resistant to *G. zeae* stalk rot. To what extent these have been evaluated may be judged best from the frequency distribution patterns of those inbreds alone or in hybrid combination classified according to stalk rot disease index values and percentage of internodal area rotted. In those distributions near normal type, skewed normal type and J-shaped curve distributions were obtained. From the standard deviation values obtained for the normal distribution for stalk rot disease index values one can readily apply the yardstick of one, two or three times the standard deviation value from the mean to detect or select inbred lines or their hybrids that differed from the mean by corresponding probabilities of approximately 66, 95, or 99 percent. The same yardstick cannot be applied accurately to distributions that deviate markedly from the normal. In that case a different yardstick would have to be applied.

The feasibility of measuring the stalk rotting propensities of inbred lines through their performance in hybrid combination appeared to be only fair in the present study as low, but highly significant correlation coefficients of +0.404 and +0.332 were obtained between 80 inbred lines and their hybrids for responses to G. zeae and D. zeae injections, respectively. Such low values would mean, therefore, that one would be more certain of choosing resistant or susceptible inbred lines if he would make the selections at the extremes of the bivariate distribution. Such a limitation of the choice should impose no serious difficulty as a few inbred lines are needed in the making of a hybrid, unless the lines so chosen possess undesireable qualities.

The low correlation coefficient between inbred lines and their hybrids in stalk rot reaction to G. zeae and to D. zeae injections poses the problem of accounting for the low coefficient. A number of possible reasons present themselves, but perhaps the most important would be the difference in the internal physiology of inbred plants as compared to their hybrids, apart from the factor of diluting their genetic constitution by one-half. Such differences occur in the phenomenon of hybrid vigor and presumably the same would apply to stalk rot reactions one way or another. In the present study, the average stalk rot disease index of hybrids injected with G. zeae or D. zeae was essentially the same as that of inbreds making those hybrids, meaning that some hybrids were more or less susceptible than their inbreds. Also in this study the stalk rot disease index of hybrids injected with water was uncorrelated with the same index derived from the inbreds making those hybrids. The latter situation further supports the idea that a fundamental difference exists in the internal physiology of inbreds versus hybrids.

The problem of accurately assessing the extent of the rot attributable to other micro-organisms that accompany these fungi was not wholly resolved in the present study. Subtraction of the rot obtained from water injections only slightly lowered the correlation coefficient between _G. zeae_ and _D. zeae_ induced rots in both Plant Pathology Department and Agronomy Department inbred lines while it raised the coefficient slightly in the hybrids from the Plant Pathology Department inbred lines. The correlation coefficients between inbred lines and their hybrids however, were markedly lowered to non-significance when a similar subtraction was made. The difference between these two situations at the moment is unexplained as a similar lowering was obtained whether the subtraction was applied only to the inbred lines or to the hybrids of those lines.

The difference in the stalk rotting propensities of Agronomy Department inbred lines and Plant Pathology Department inbred lines was so striking in the present study that one wonders why this was so. Although the writer has no answer for the difference, the possibility exists that the difference was associated with the purpose for which the inbreds were developed. The Plant Pathology Department inbred lines were developed for root rot resistance and good root qualities, while the Agronomy Department inbred lines were developed for vigor and for tendencies to impart earliness and yield to hybrids. Perhaps stalk rot resistance is associated with good root qualities and root rot resistance.

The significant to highly significant but low correlation coefficients obtained between unsubtracted G. zeae and D. zeae stalk rot indices obtained among inbred lines and among hybrids and between unsubtracted G. zeae or D. zeae stalk rot indices and water induced indices in the same situation points to a general similarity of action of these agencies. On this basis one might suppose that stalk injection with one agent generally would yield the same result as injecting with another. The inadequancy of this supposition becomes apparent however, when one views the frequency distribution patterns of the corn lines or hybrids classified according to disease index values or to percentage of internodal area rotted. In those distributions the separations of the corn lines or hybrids becomes much greater when injected with D. zeae than with G. zeae, and only slightly greater when injected with G. zeae than with water. Hence if a choice is to be made for only one kind of injection, then D. zeae should be the one.

SUMMARY

Eighty inbred lines and their hybrids from top cross combination with SD26 x B8, produced by the Plant Pathology Department, South Dakota Agricultural Experiment Station, and 68 inbred lines, produced or acquired by the Agronomy Department were injected in the field in 1960 with water, G. zeae and D. zeae. Three plants of each inbred or hybrid in each of three random block replications were each injected in the center of two internodes at pollination. Holes made with a handled 8-penny nail at the injection point were filled with water or with aqueous suspension of sporulated agar cultures of the fungi. The holes were covered immediately with petrolatum and the stalks were split four weeks later when the percentage of internodal area rotted was visually indexed on a 1 to 10 logarithmic scale.

From the analysis of variance of stalk rot disease index data, highly significant variances among inbred lines and hybrids were evident from injections with each of water, G. zeae and D. zeae. The variances due to replication were non-significant in all instances except from D. zeae injections of hybrids, where the significance exceeded the 5 percent level of probability.

The average stalk rot disease index from water, G. zeae and D. zeae injection for the Plant Pathology Department inbred lines was 2.5, 4.0, 5.3; for the Plant Pathology Department hybrids was 2.8, 3.9, 6.0; and for the Agronomy Department inbreds was 3.0, 4.8, and 7.0, respectively.

The frequency distribution of inbred lines and hybrids classified according to disease index values and percentage of internodal area rotted approached normal type, skewed normal type and J-shaped curve patterns with greater overlapping between G. zeae and water distribution than between D. zeae and the other distributions. Diplodia zeae appeared to be a more discriminating pathogen for stalk rotting evaluations than G. zeae.

Significant to highly significant, but relatively low correlation coefficients in disease index values were obtained between the three kinds of stalk inoculations with the Plant Pathology Department inbred lines and hybrids, while highly significant and larger correlation coefficients than these were obtained between these same kinds of stalk inoculations with the Agronomy Department inbred lines.

Subtracting the disease index values obtained from water injections from those obtained from G. zeae or D. zeae injections only slightly lowered the correlation coefficients otherwise obtained between these fungi in the Plant Pathology Department and Agronomy Department inbred lines, while it raised it slightly in the Plant Pathology Department hybrids.

The stalk rot disease index values of the Plant Pathology Department inbred lines and their hybrids were significantly correlated at the 1 percent level of probability for G. zeae ($r=+0.404$) and for D. zeae ($r=+0.332$) but were uncorrelated for water injection. Subtraction of the disease index value for water injection for either or both of the inbred lines and hybrids from those of G. zeae or D. zeae values lowered the correlation coefficient to non-significance.

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